Chapter 1
Introduction

1.1 General

Construction output[1] in the United Kingdom represents approximately 7% of the UK Gross Domestic Product (GDP[2]). In the United States, the proportion for construction output, including manufacturing and mining, constituted 17% of the GDP output[3] for 2013 with construction output alone valued at around $900 billion.[4] Construction is a unique industry due to it being a fast-moving, complex and dynamic process which depends on the successful coordination of multiple discrete business entities – including professionals, tradesmen, manufacturers, trade unions, investors, local authorities, specialist trade contractors and so on to ensure the delivery of a project on time, within budget and of the required quality. This coordination is dependent on the application of sound planning, programming and project controls, allied to the implementation of tried and tested management techniques. Much of this work is carried out using increasingly sophisticated computer applications that are continually advancing by offering more and more capabilities to the end user.

A survey[5] carried out among UK contractors in the mid-1990s found that 49% of contractors did not use computers on construction site locations. Now, not only are computers commonplace in one form or another, but also the use of specialist planning software is common as is computer-aided delay analysis.

Risk is an inherent feature of construction, and it is well known that 'no construction project is risk free. Risk can be managed, minimised, shared, transferred or accepted. It cannot be ignored[6]'. If it is accepted that risk is inherent in construction, then it must also be accepted that the likelihood of delays is also inherent in the process and should

[1] Estimated annual volume of construction output in 2013 was £112.6 billion [online] Available at http://www.ons.gov.uk [Accessed 26 May 2014].
[2] UK GDP forecast for 2013 is £1581.2 billion [online] Available at www.ukpublicspending.co.uk [Accessed 26 May 2014].
[3] United States GDP Growth Rate [online] Available at www.tradingeconomics.com/united-states/gdp-growth [Accessed 26 May 2014].
[4] Wiggins T., 2014. *U.S. Construction Outlook for 2014.*
[5] Keane P. J., 1994. *Survey on Computer Usage in Construction Claims Management*.
[6] Sir Michael Latham, 1994. *Constructing the Team.* Final Report. HMSO.

Delay Analysis in Construction Contracts, Second Edition. P. J. Keane and A. F. Caletka.

therefore be anticipated, managed and treated in a similar fashion as risk. When delays are experienced, this is not necessarily an indication that the process or management team is breaking down. Delays are often simply the result of an event which must be managed by a systematic process so as to anticipate the impact of that event on the programme and to minimise the risk of further delay. Systematic management of delay during the course of a project also ensures that the cause of that delay is identified, and documented, at the earliest opportunity. When there is a requirement to identify the cause and effect of delay to establish entitlement to additional time or money, the results of any relevant analysis should be capable of being presented in a clear and unambiguous way.

The most significant unanticipated cost in most construction projects is the financial impact associated with delay and disruption to the works. Assessing the impact of delay and disruption and establishing a direct causal link from a delay event ('cause') to its impact ('effect'), the liability and resulting damages, can be difficult and complex. Contractors and subcontractors require these skills for successful evaluation and presentation of time delay claims. The employer's professional team also requires similar skills and techniques when analysing and evaluating extension of time entitlements under a construction contract. Where these delay issues are not resolved by the contract administrator and contractor in the normal commercial way, then such issues are often left to be decided by third parties in arbitration or adjudication, before dispute review boards or, ultimately, in litigation. All these steps within the dispute resolution hierarchy have different timetables and expectations regarding the evidence required to demonstrate cause and effect. In selecting the most appropriate technique to suit the project and to ensure proportionality is maintained, the following factors must be considered: the relevant facts, the timetable, the nature and number of delay events and the size of the potential dispute.

1.1.1 Purpose of this book

The purpose of this book is to provide a practical guide to the process of delay analysis for programmers and delay analysts and to inform non-programmers of the nuances of delay analysis techniques available. The book also considers the assumptions which underlie the precise calculations of a quantitative delay analysis, in order to 'level the playing field' for non-programmers and experts alike. This entails an in-depth review of the primary methods of delay analysis in use today, along with some familiar secondary methods. The timing and purpose of delay analysis is also discussed, together with a review of the fundamentals of critical path method (CPM) programming. The 'project control cycle' is also described in detail. Contemporaneous programming evidence, whether flawed or not, will usually be preferred to retrospectively created programme data, so the emphasis should be on establishing and maintaining an accurate and effective CPM programme throughout the performance of the works.

This book is intended for project and construction management practitioners, contract and legal advisors and programming consultants alike, who not only seek an understanding of the principles, techniques and methodologies involved in the process of delay analysis but also want to understandw the techniques and underlying processes in some detail. Such individuals include those employed by project owners (employers), contractors/subcontractors, legal experts and consultants who often find the need to manage extension of time or delay claims.

The techniques discussed in the book can be used on projects under all forms of construction contract, both domestic and international. Disputes involving delay entitlement and quantification, and which have to be resolved by the intervention of a third party trier of fact, are a frequent occurrence in the construction industry. Over the years, judicial decisions on several key aspects of delay dispute have been handed down by the courts, which have assisted, to some extent, in shaping the way in which delay analysis is undertaken in certain aspects. However, while the implications of these decisions clearly have a great bearing on the work of a delay analyst, it must be remembered that most, if not all, decisions regarding delay analysis are made not necessarily on the method of analysis, but rather on the underlying facts presented and relied upon.

The courts are only presented with delay issues after the event, and therefore decisions handed down mainly provide guidance on retrospective delay analysis techniques which demand, and rely upon, a high level of accuracy and detail with regard to the as-built programme. Notwithstanding the influence of the courts on the process of developing claims for delay and disruption, in order to accord with the ethos of this book, and the actual circumstances and facts many construction professionals find themselves managing, the authors have restricted the use of case law references to a minimum; for instance, where a principle has clearly been established and is commonly referred to in delay claims. Where cases have been referred to, this has not only been restricted to English case law but also includes a small number of significant US cases which are relevant to topics addressed. The US courts have accepted the concept of CPM programming and computer-generated delay analysis submissions since the early 1970s. The English courts appear to lean in the direction of 'common sense', whereby the method of analysis is secondary, whether CPM programming techniques were relied upon or not.

It is important that a delay analyst should not become blinkered or be constrained by past judicial decisions in devising and applying delay analysis techniques prospectively in a live project environment. If a delay analyst adopts an unorthodox approach which is acceptable by both parties and resolves a time entitlement claim, then that is to be commended. In the same vein, it is important not to get too hung up on 'named' approaches; this is largely another spin-off from judicial involvement in the development of delay analysis. Such named approaches include 'time impact analyses', 'as-planned versus as-built' and 'collapsed as-built' (CAB). These names really only start to have any significance when used as expert evidence to provide a general indication of the approach being adopted by the delay analyst. Even so, there has been little guidance, until recently, as to how each method should be carried out. The primary named methods are often misused in court proceedings, arbitrations and adjudications.

Court decisions and arbitral awards sometimes indicate either a lack of willingness to come to grips with the issues and terminology or a difficulty in fully grasping the intricacies of sophisticated delay analyses. This is entirely understandable as judges are not usually presented with easy issues. The complexity of even the simplest of construction processes often proves to be extremely difficult to convey. Also courts, along with parties' legal advisers, are not always assisted by delay analysts who misdescribe or misapply these techniques and opposing experts who do not take one another's approach 'head on'. When two opposing party appointed experts refuse to engage the other's method of analysis, this leaves a void where agreed programming evidence should be. These cases often conclude by the tribunal making an assessment based on the facts.

In summary, it is somewhat arbitrary to 'badge' and thereby restrict a piece of analysis, and while reference is made in this book to the primary delay analysis approaches, the authors urge caution in becoming too prescriptive because even these primary methods have secondary derivatives and many variations as to how they can be carried out. Also, for this reason, the authors have restricted the use of case law references to a minimum, to allow the site-based practitioner to make informed judgement calls when developing a delay claim rather than simply discounting one method of delay analysis over another, based on his or her understanding of the latest judicial decision mentioning a method of delay analysis being applied by either party.

This book discusses delay analysis techniques and approaches, with their appropriateness under given circumstances, and demonstrates how a combined, or hybrid, approach can be applied, complete with worked examples and case studies. Delay analysis is becoming an increasingly complex activity and there is continual debate and commentary on the primary approaches available. This book brings together the main techniques available in comprehensive primary and secondary categories. The particular techniques described in this book have been successfully tried and tested by the authors in both the commercial environment and in dispute resolution proceedings: adjudication, arbitration, dispute review boards and litigation. This book will serve as a resource guide for those practitioners, advisors, clients or contractors preparing or responding to construction delay claims.

1.1.2 Guidance

Two major guides have been produced on both sides of the Atlantic to assist those dealing with time extension claims and delay analysis. The first is the Society of Construction Law's Delay and Disruption Protocol, published by the Society in October 2002[7] (SCL Protocol). The stated aim of the SCL Protocol is to provide useful guidance on some of the common issues that arise on construction contracts, where one party wishes to recover from another an extension of time and/or compensation for the additional time spent and the resources used to complete the project. The second more recent guide was published by the Association for the Advancement of Cost Engineering International (AACEI) in the form of its 'Recommended Practice No. 29R-03 *Forensic Schedule Analysis*[8]' (RP-FSA). This document, issued on July 1, 2007 was officially launched on July 15,

[7] The SCL protocol can be downloaded from http://www.eotprotocol.com.

[8] Association for the Advancement of Cost Engineering International – Recommended Practice No. 29R-03 *Forensic Schedule Analysis*.

2007. The RP-FSA is primarily focused on the terminology and the application of forensic analysis and is a much more technical document than the SCL Protocol, although it does not address as broad a spectrum as the Protocol. The stated purpose of the RP-FSA is to provide a unifying technical reference for the forensic application of CPM scheduling and to reduce the degree of subjectivity involved in the current 'state-of-the-art' concept while the state of the art in the United States differs from the state of the art in England. Both of these documents are discussed and contrasted in Chapter 4.

1.1.3 Construction planning and programming

Most construction projects will benefit from CPM programming. Only the most basic of projects can and should be planned and managed intuitively. The rest require systematic planning and control. Over the past 30 years, planning and programming have been fundamental building blocks in any project management and control system and, in some organisations, are given equal weight with the budgeting and cost management functions.

CPM is the planning technique most commonly used in the construction industry today and is based on the same critical path analysis principles established in the 1950s. In Chapter 2, the principles of construction planning and programming are explained. These techniques are fundamental in enabling a project to be successfully managed. CPM programming is a tried and tested method and is today essentially unchanged from the earliest applications almost 60 years ago. The chapter describes the essential elements of a successful project through the planning and programming phase and identifies the pre-construction tasks which not only are prerequisites to effectively planning a project but also, conversely in the case of insufficient pre-construction planning, can result in programmes being developed which contain inherent delays.

The stages and life cycle of a construction project are described in detail. The project planning stage is the most important to the development of an effective baseline programme. During the planning stage, the project definition is established. Executing a successful project requires a significant pre-construction effort which questions the underlying assumptions and business case for the project. During this stage, the professional team considers such issues as whether a project is feasible and buildable, whether any new or novel method of construction will be required and whether there are technical, geographical, time and/or financial constraints which would prevent the success of a project.

Chapter 2 also discusses the process of preparing a construction programme, the creation of a work breakdown structure and the fundamentals of CPM programming.

A significant aspect of delay analysis is the interrogation of records upon which reliance will be placed in analysis output. Accordingly, the need for good records and the various categories of required record keeping are explained. Finally, there is a cautionary note on predatory programming practices which should be avoided, along with advice as to how to detect and defend against each.

1.2 Construction delays

1.2.1 Identifying delays

The identification and assessment of delay entitlement can be difficult and time-consuming. When any degree of complexity is introduced to the mix, it can become particularly difficult for project staff who are often overworked dealing with site issues and other project demands, and who may also be untrained in forensic analysis or programming skills. This often manifests itself as a poor strike rate in achieving extensions of time entitlements by contractors. When the employer's team lacks these skills and awareness, the risk is created of granting inadequate or excessive extensions of time to contractors. To be successful, a time extension claim should adequately establish causation and liability and assist in demonstrating the extent of time-related damages or disruption costs experienced as a direct result of the delay events relied upon. The purpose of delay analysis is to satisfy the causation requirement in such a way that it can be used to assess the resulting damages.

Establishing a basis for identifying delay is the first topic dealt with in Chapter 3. This chapter also deals with the construction phase of a project, as that is generally where the bulk of a project budget is usually dedicated. The construction phase is also the phase in which design delays, or lack of sufficient pre-construction planning, will often culminate into critical delays to completion, as measured by delays to site activities.

Delays may be categorised as excusable, non-excusable, compensable and non-compensable. When demonstrating that a delay is both excusable and compensable, the delay must be shown to be critical, by reference to a reliable critical path analysis. The tests which must be satisfied for a delay to be considered excusable and compensable are described and discussed in Chapter 3.

The carrying out of a successful delay analysis requires the preparation of a reliable as-planned programme and an accurate as-built programme. The effectiveness of delay analysis techniques can be greatly increased when it can be demonstrated that the as-planned programme was reasonable. Further discussion on as-planned programmes is also to be found in Chapter 2. The as-planned or baseline programme is useful contemporaneous evidence of a contractor's original intentions and should serve as the starting point when identifying delays. Unfortunately, there are many ways in which as-planned and progress programmes can be manipulated. Chapter 3 highlights checks that should be made to validate the reliability of such a programme before it should be used for any method of delay analysis.

One of the main objectives of delay analysis is the establishment of a factual matrix and a chronology of the events which actually delayed the project's completion date. One important use of this data is to assist in the preparation and/or validation of an as-built programme. In the ideal situation, an as-built programme will have been prepared and maintained during the course of the works. The data required to periodically maintain and update a project programme can also be relied upon when forensically constructing an as-built programme. The primary sources of raw data required for the compilation of an as-built programme are discussed in Chapter 3, together with a cautionary note about the use of lazy scheduling practices, such as the overuse of constraints, negative lags and 'auto update' functions, which can be found in commercially available planning software.

The process of identifying delay events is a fundamental aspect of delay analysis and can be undertaken in two primary ways: either an 'effect-based' approach or a 'cause-based' one. Both of these are explained in Chapter 3, along with a discussion on contractor and employer risk events.

While this book is principally concerned with delay analysis, it is inevitable that the issue of disruption will have to be dealt with to some extent. Chapter 3 is confined to a general overview of disruption, particularly its interface with delay analysis. In the construction industry, delay and disruption are two terms that are often used in the same breath. This is understandable as delay and disruption often result from the same events. However, disruption, unlike delay, always has a direct consequence on financial loss. The main differences between delay and disruption are discussed, together with a review of the many causes of disruption, and factors that affect productivity. An example of calculating disruption is illustrated.

If there is no agreed model or method for quantifying the effects of disruption factors in advance, the establishment of the magnitude of the disruption or loss incurred will likely require the preparation of expert evidence. Accordingly, a number of approaches have been developed which include the measured mile, measured productivity method, work sampling, modified total cost approach and site sampling (time and motion studies). These are discussed along with brief practical examples which are provided to assist in demonstrating the process of each type of analysis.

1.2.2 Analysing construction delays

The effect of delay and disruption can be identified and assessed using several dissimilar techniques. There is much discussion about the various approaches to delay analysis along with explanations as to why it should not be surprising when two opposing programming experts can apply the same technique and produce widely varying and inconsistent conclusions. Delay analysis techniques are known by many generic titles and each method can be applied in several ways. The most widely known methods of delay analysis are subject to frequent misuse, but the name applied to a technique is not as important as the application of the chosen method. All commonly applied forensic delay analysis techniques generally fit within one of the following primary categories: impacted as-planned, collapsed as-built (CAB), as-planned versus as-built and time impact analysis (TIA).

The 'windows' method is also described in detail, using several of the primary methods listed above. The term 'windows' simply refers to the period of time being analysed. When key milestones are relied on, the same approach is sometimes referred to as 'watershed' analysis. Each of these primary delay analysis techniques has secondary derivative methods of application, which may be used in prospective or retrospective settings. All of these named techniques are fully explained in Chapter 5, which also not only explains how to carry out and present several secondary derivative methods but also contrasts the strengths and weaknesses of each method and considers the underlying assumptions the analyst must make when using any of these techniques. The four primary methods of delay analysis are also reviewed in detail in Chapter 5, complete with a step-by-step guide to their usage and an indication of some secondary approaches which can be derived from each of these primary approaches.

The chapter also explores the use of CPM and total float management techniques relative to delay analysis. CPM programming is essential when attempting to identify which activities are either critical or non-critical. The CPM programme is therefore the key to demonstrating those events which actually contributed to the critical delay to completion and those which may be deemed merely concurrent 'events'. The concept of 'pacing' is also explained in detail. In the US courts, the use of CPM programmes to demonstrate delay has been a requirement for some years, to the point where delay analysis in US courts almost exclusively rely on delay analyses which used CPM methods of proving entitlement.

There are many names used in the construction industry for the 'TIA' approach, probably because there are as many ways to apply the technique. A summary of the perceived strengths and weaknesses of the TIA technique are summarised in Chapter 5, along with many of the variations and options available to the analyst when carrying out this technique.

The 'collapsed as-built' (CAB) approach is a modelling technique which is traditionally carried out on a single-base programme, for example the as-built programme. The other side of the spectrum of the basic methods of analysis includes as-built based analytical techniques which do not rely on calculated CPM models. In its simplest form, an as-built versus as-planned analysis compares the planned duration with the actual duration of a project and asserts the difference as being both excusable and compensable. These are referred to as 'Observational' in the AACEI RP-FSA.

On projects where the effects of acceleration (or attempted acceleration) or early completion programmes are at issue, it advisable to apply both a deterministic technique and an analytical technique, which is explained in Chapter 5. This provides a tribunal with a range of opinions, based on different assumptions.

The contemporaneous windows analysis is a technique which relies on the analysis of contemporaneous progress information and is considered to be dynamic because it considers the dynamic nature of the critical path. The as-built critical path of a programme shifts from time to time for many reasons as explained in Chapter 5.

A similar method to the contemporaneous windows analysis is the 'month-to-month update' analysis, whereby the progress achieved in 1 month, is superimposed on a previous month's programme update. This is a method which discretely determines the loss/gain experienced due to both progress achieved/not achieved, and programming revisions made by the contractor. This is a form of 'what if' analysis, which identifies and isolates delays caused purely by progress, from delays (or gains) which resulted from changed logic, constraints or durations. This method of analysis is very effective when a contractor is seeking to demonstrate acceleration and needs to demonstrate what the 'likely' effect of a delay event would have been, as opposed to the 'actual' effect. The case study in Chapter 7 applies this technique in a worked example.

Determining which technique is the most appropriate to use under given circumstances is a subjective decision, guided by experience, the available information and other relevant factors. Even when agreement is reached between the parties, often the application of the same 'technique' varies to such an extent that neither party is willing to accept the other's conclusions. These issues have been addressed in both the SCL Protocol and the AACEI's RP-FSA. Chapter 4 provides detail of the SCL Protocol and the 21 core principles. The approach to event analysis and delay quantification must be both systematic and pragmatic. Notwithstanding the importance of this activity, it is also essential to keep a sense of balance with regard to what is a proportionate cost-to-benefit ratio and to avoid overly complex analyses. These may be accurate, or precise, but may not be intuitive, at the risk of conflicting with a tribunal's view of 'common sense'. While courts have judicial latitude, contractors and contract administrators cannot be seen to base extensions of time on impressionistic assessments. The methods set out in Chapter 5 assist parties in arriving at an approach that is pragmatic, systematic and appropriate for the circumstances of their project.

1.2.3 Delay claim life cycle

Each and every delay claim has its own life cycle. The various stages may be summarised as follows:

- Baseline programme is established
- Project commences
- Deviation from baseline programme is identified (or projected)
- Delay occurrence/discovery
- Delay analysis
- Delay claim submission and presentation
- Delay claim response
- Negotiations (and award of appropriate extension of time)
- Revised baseline programme is established and agreed
- Dispute resolution procedures (if award is not agreed)
- Delay claim resolution

Delay claims are a very effective way to spend money and divert management resource from running a business. Resolution by way of a mutually acceptable extension of time should be sought at the earliest opportunity to avoid the dispute stepping up to the next, more formal process. There are many pitfalls on the path to a successful delay claim resolution as well as steps that can be taken to improve the outcome. For example, the contracting parties could agree the delay impacts contemporaneously (i.e. as they arise during the course of the project works) rather than adopting a 'wait-and-see' approach. Chapter 6 considers a number of problematic issues which arise in connection with both programming and delay analysis. These include problematic issues related to the ownership of float in construction programmes, concurrency, programme submission and approvals, acceleration, disruption and mitigation of delay.

Effective communication of sophisticated delay analysis requires quality in the presentation. There are many ways to present similar facts with different conclusions. The benefits of visual aids with worked examples are explained in Chapter 7, together with methods of graphical presentation that are described and critiqued. In addition, a number of worked examples are included and case studies explained.

1.3 Burning issues in delay analysis

Chapter 6 discusses a number of problematic issues which have arisen in connection with both programming and delay analysis. These include:

- Issues related to the ownership of float in construction programmes
- Concurrency
- Programme approvals
- Mitigation
- Acceleration
- Pacing
- Contractors' entitlement to early completion
- The assessment of disruption damages

Float is an integral part of CPM programming and delay analysis. The concept of float, which has given rise to much debate, is introduced in Chapter 2 and further explained in Chapters 4 and 5. In Chapter 6, float is discussed in detail, relative to its usage, measurement and ownership. Float loss can reduces a contractor's contingency time cushion and increases the probability of critical delay to the project. Even where it does not result in critical delay, float loss can cause financial loss to discrete task related resources. Chapter 6 discusses float loss measurement and also ways in which both employers and contractors can seek to influence a programme, and ways in which planners can manipulate float using various float suppression techniques. An issue of much debate for many years is 'who owns the float in a construction programme?'; the implication being that the owner of the float has exclusive use of it. Chapter 6 reviews the various viewpoints on this matter.

Another common problematic issue, which arises in delay analysis, is that of dealing with, and defining, concurrent events and concurrent delay. The uncertainty as to how concurrent delay should be managed or defined continues to cause difficulty to contract administrators, in particular in their task of assessing extensions of time and compensation events during the course of a project.

These issues impact both on the level of extension of time that might or might not be granted and on the amount of compensation, for example loss and/or expense, that might be due. Chapter 6 reviews definitions of concurrency and considers alternative approaches for dealing with concurrent delay including 'first-in-line', the dominant cause approach and the apportionment approach. When concurrent culpable delays are identified by the employer, contractors often argue that it was simply 'pacing the work'. This concept is discussed, including how it might apply equally to the employer's professional team as well as to contractors.

Another area of potential difficulty is that of programme approvals and onerous specifications. Many of the major building and civil engineering forms of contract require the contractor to prepare and submit a construction programme. The content and standard of construction programming data that employers have required to be submitted by contractors in the past has varied quite considerably. However, in more recent times, with the advances in computer generated output and a growing awareness of the nature of construction planning, employers have been requesting ever increasing detailed and sophisticated programmes from contractors. In the United States, particularly on government forms of contract, it is a more common practice to require quite detailed and sophisticated programme requirements. These issues together with approval or acceptance of construction programmes are discussed in Chapter 6.

The final issues reviewed under this chapter are those of delay mitigation, acceleration and contractors' rights to early completion. The latter topic is when a contractor submits a programme which indicates an intention to finish a project earlier than the agreed contract completion date.

1.4 Presentation and case study

Effective communication of sophisticated delay analysis requires quality and sufficient level of detail in the presentation. It has been established that people usually understand and retain information at a much higher rate when it is presented to them visually. Studies in the United States have shown that jurors, for example retain as little as 10–20% of the material presented to them orally yet retain as much as 65–80% of material presented to them visually or with visual supplements. The effect of using high-impact, demonstrative evidence assists greatly in the success of a case which includes complex technical issues. There are many ways to present similar facts with different conclusions. The benefits of visual aids with worked examples are explained in Chapter 7 together with methods of graphical presentation which are described and critiqued.

In addition in Chapter 7, various methods of delay analysis are demonstrated using a case study, largely based on actual assignments. The information available on the case study project is listed and the method of identifying the as-built critical path is described in detail. The purpose of this chapter is to show how these methods of delay analysis may be carried out. It is important to note that the methodology demonstrated in this case study is neither the only one, nor the only variant on the method demonstrated, for carrying out this type of delay analysis.